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Military Operations Research in China (U)

A Defense S&T Intelligence Study

Defense Intelligence Agency

US Army Foreign Science and Technology Center

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MILITARY OPERATIONS RESEARCH IN CHINA (U)

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PREFACE

(u) [redacted] Military science, including military operations research (MOR) and systems engineering, was embraced by the Chinese in the early 1980s. Since that time, Chinese developments in the area and their efforts to develop simulations have followed those of the West. These efforts have played, and continue to play, an important role in China's modernization efforts and have permeated all aspects of defense planning and building within China. This study provides an introduction to the development of MOR in China; identifies key Chinese research institutes and 'think tanks' involved with MOR; describes MOR-related products with emphasis on tactical engagement simulations and training simulators; identifies the effects of technology transfer on Chinese MOR efforts; discusses the quality and success of Chinese efforts in MOR; and forecasts the future of MOR in China relative to China's modernization efforts, technology developments, and limitations.

(U) Simulation systems can include a variety of systems ranging from a mathematical model to a computer-based system to a physical mockup of the original system. For the purposes of this study, the terms simulation and simulator refer to systems that, based on our research, appear to incorporate the use of a computer(s) to emulate the function(s) of a system or the processes involved in the interaction of systems and humans in events ranging from combat operations to negotiation processes.

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(U) This study is intended to aid US research-and-development personnel in evaluating the threat and designing systems to counter it. Army requirements addressed in this product include AMC-92-K1-S-003 and AMC-93-A1-S-003.

(U) Constructive criticisms, comments, or suggested changes are encouraged and should be forwarded to the Defense Intelligence Agency, Washington, DC 20340-6150 (ATTN: PAN-2A).

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KEY JUDGMENTS

(U) The key judgments derived from this study of Chinese military operations research (MOR) are as follows:

- (U) During the 1980s, MOR became an integral part of China's program for defense modernization.
- [redacted]
- (U) Chinese work in nonlinear systems, particularly dissipative structures, synergetics (or complexity), and catastrophe theory, for MOR applications is probably near or at the level of Western research.
- (U) Chinese tactical engagement simulations are modular in design, often building on previous work and models. Chinese simulation research is closely following Western research efforts in the areas of combined-arms operations, real-time operations, audio-visual aids, and the use of expert systems.
- (U) China claims to be the first country to have developed a simulation system for chemical defense training and operation. It is also one of the few countries with a campaign training simulation system.
- (U) China's training simulator program is marked by uncontrolled development, duplication, lack of coordination, and standardization. These problems are expected to severely hinder China's near-term goal of developing a complete training system with integrated and distributed simulators. The lack of standardization also limits the benefits derived from the use of training simulators.
- [redacted]
- (U) MOR methods have been employed in forecasting China's military needs and defense strategies for the year 2000 and beyond. Examples include a study to determine the size of the People's Liberation Army in the year 2000 and a model addressing arms proliferation and negotiation.
- (U) China is building numerous centers and laboratories for developing simulators and conducting simulations. Many of these centers are world-class facilities, whose officers are aggressively seeking foreign investment and aid.
- (U) The United States has been a major supplier of MOR technology to China, followed by the former Soviet Union and Japan.
- (U) China's current simulators are assessed to be 5 to 10 years behind world standards. A lack of computing power will be the major obstacle to China's becoming a world leader in MOR. If restrictions on the export of computers to China are lifted, China can be expected to rapidly become a

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world leader. With the restrictions remaining in place, China can be expected to continue to follow the state-of-the-art in MOR but to remain several years behind the leaders in actual developments and applications.

- (U) China's commitment to training simulators and simulation systems in the military and civilian sectors, to reducing military costs, and to modernizing its military will foster future developments in Chinese training simulators and simulation systems. These systems will be key indicators of future Chinese weapon systems, tactics, and defense strategies.

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SECTION I

GENERAL INFORMATION (U)

1. Background (U)

a. (U) The Chinese philosopher Sun Tzu is credited with the concept of using calculations in war; in the 5th century B.C. he observed:

> Now the general who wins a battle makes many calculations in his temple ere the battle is fought. The general who loses a battle makes but few calculations beforehand.

Since Sun Tzu, various writers have commented on the usefulness of quantitative studies in military analysis, but it was not until World War II that military operations research (MOR) began to emerge as a tool in Western military analysis, specifically in the development of mathematical models of conflict or wargames. The success of these models during World War II resulted in their continued use.

b. (U) Despite China's legacy in MOR from Sun Tzu, organized efforts at studying and employing operations research (OR) did not occur until 1956. Under the guidance of Qian Xuesen, a US-trained scientist, China's first OR group was organized. Subsequently, the first OR laboratory was established in 1958 at the Institute of Mathematics (later known as the Institute of Applied Mathematics) under the Chinese Academy of Sciences. In the early 1960s Professor Hua Luogen, Director of the Institute of Applied Math (1951-1966), introduced the critical-path and optimum-seeking methods and attempted to apply them to the national defense and military departments.

c. (U) Concurrent with the organization of these research groups and laboratories, Wang Chengwei was working with Soviet technicians to develop expertise in digital computers for simulation. His knowledge was key to the development of simulation software in the 1970s and 1980s in China.

d. (U) [redacted] The 1970s saw interest in MOR beginning to develop with the establishment of a five-man office for MOR and systems analysis under the Academy of Military Science (AMS). A few symposia and conferences in the subject area were also sponsored by the Chinese Aeronautics Society, Navy, and National Defense Science, Technology, and Industry Commission (COSTIND). However, China's plan for four modernizations (i.e., to double China's gross national product by the year 2000 and quadruple production in four areas: agriculture, industry, science and technology, and defense) set the stage for the growth of OR. A 1979 speech titled "Military System Engineering" by H. S. Tsien to high-ranking People's Liberation Army (PLA) officers may have been the catalyst behind the sudden attention given to MOR during the 1980s. In his speech, Tsien stated:

> Tactical simulation techniques provide an 'operational laboratory' in essence, in which simulated operational environment is made use of to experiment on tactics and plans, to examine their weaknesses, to predict their effect, to assess weapon systems' operational efficiency, and to inspire new operational concepts. Tactical simulation techniques lead the systems engineering methodologies of modeling, simulations, and optimization into military decision making.

e. [redacted] This speech was given at a time when China's defense strategies and goals were changing from war preparation to economic construction and force modernization. These changes were coupled with reductions in defense spending. [redacted]

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[redacted] As a result, the PLA began to establish MOR and systems engineering societies, organizations, and institutes to address OR issues, support the development of models and simulations, and establish contacts with the West in the subject area. By 1983 applied research into tactical engagement simulations (TES), or wargames, had begun, and by 1984 military science had been designated an official subject in China's national science curriculum with particular emphasis given to OR [redacted] Figure 1 shows other MOR-related events within China during the 1980s.

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- 1980
  - Chinese Systems Engineering Society established
- 1981
  - Committee for Military Systems Engineering established
  - Conference on Computerized War Games held
- 1982
  - Two symposia on computer wargaming held
  - Modern War Games published
- 1983
  - Seminar for Models and Data on Computer Wargaming held
  - Symposium for the Design of Administrative Software Systems held
  - Second Annual Conference on Military Systems Engineering held
- 1984
  - Symposium for Application of Microcomputers in Military Systems Engineering held
  - Military science designed official subject
- 1985
  - GSD training delegation visits United States
  - NDU and Army Command College wargaming centers established
- 1986
  - BISE founded
  - Symposium on Defense Strategy and Systems Engineering to the Year 2000 held
  - 863 High Technology Research and Development Plan established
- 1987
  - US/China Defense Systems Analysis Seminar (Beijing) held
- 1988
  - Second US/China Defense Systems Analysis Seminar (Newport, RI) held
  - US Army Training and Doctrine Command representatives visit China
- 1989
  - Military Expert System and Artificial Intelligence Conference held

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Figure 1. (U) Military Operations Research Related Events During the 1980s

(U)

f. [redacted] A new strategic policy adopted in 1981 by the Central Military Commission (CMC) and a 1981 paper by Zhang Zhen calling for training reforms emphasized the use of simulators and audio-visual equipment for training. As a result, a 5-year plan for development and production of simulated training equipment for the PLA was drafted. In 1986, production of electronic training equipment replaced capital construction as a priority goal.

g. [redacted]-WN-NC-PR-OC) [redacted]

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h. (U) Another important area under the 863 Plan is the Computer Integrated Manufacturing System project. Based on this study's focus on military-related simulations this project is not addressed; however, simulation will be a key technology in the project's success.

i. [redacted]

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[redacted]

j. (U) Also for the first time during the 7th FYP, China organized more than 100 specialists and professors in the scientific and technological fields into groups to assist in formulating major science-and-technology-related policies and decisions. These groups discussed, analyzed, and evaluated all the major problems related to scientific and technological plans including military simulation and computer technology for the 7th FYP. They also provided direction for future development, recommended key and intermediate targets, and set priorities for research projects. The members of these groups, who came from more than 50 scientific research institutions, colleges, and universities, also established contacts with other experts in related scientific and technological fields forming a national technical consultation specialist network with over 1000 members.

k. [redacted] As a result of China's increased efforts in MOR during the 1980s, the Chinese soon recognized the benefits of simulations. Key among these benefits was the reduction in costs for training and system development. [redacted]

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2. <u>China's MOR Infrastructure (U)</u>

a. <u>Introduction (U)</u>.

(1) [redacted] COSTIND is directly subordinate to the CMC and coordinates all Chinese OR activities within the defense industries and military research and development (R&D) institutes. The Deputy Secretary General of COSTIND's Science and Technology Committee is Wang Shouyun, author of

Modern War Games (1982). The Beijing Institute of Systems Engineering (BISE) serves as the primary coordinator of all OR activities for COSTIND. Other important institutions in MOR are AMS and the National Defense University (NDU). Figure 2 is an organizational chart reflecting the relationships between these organizations, the service branches of the PLA, and the China Defense Science and Technology Information Center (CDSTIC). [redacted]

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(2) (u) A growing number of societies within China are involved with MOR, systems engineering, and simulation. Numerous military colleges have also introduced OR, control theory, systems engineering, information theory, and electronic computer science into their curriculums since 1984, when military science was designated an official subject. Most are also involved in mathematical modeling and the development of computer models and simulators.

(3) (U) This section identifies some of the key institutes and societies in MOR.

Other institutes involved in the development of simulation systems and MOR models are identified in the appendix.

b. Beijing Institute of Systems Engineering (U).

(1) [redacted]

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(2) [redacted]

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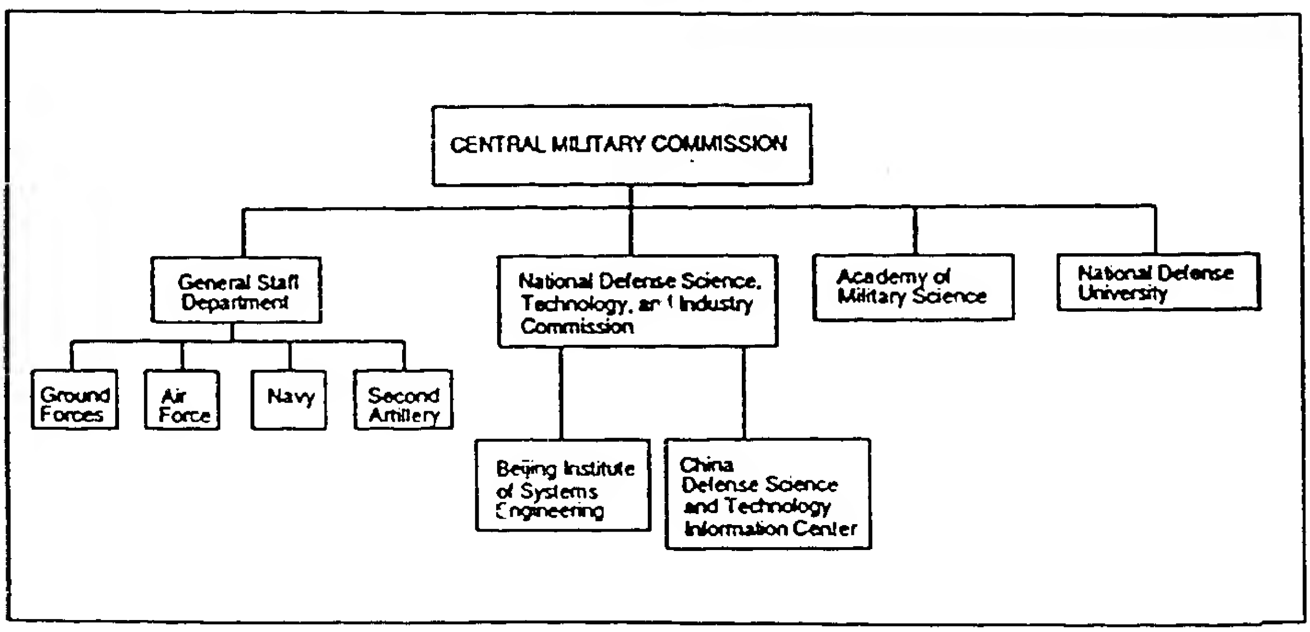

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Figure 2. (U) Organizational Chart of MOR-Related Institutes and Organizations in China.

[redacted]

(3) [redacted]

(4) [redacted]

c. Academy of Military Science (U).

(1) [redacted] AMS was founded 15 March 1958 and became a military academic element under the direct supervision of the CMC in 1986. Since that time, AMS has been one of the leading elements in China trying to modernize the military and transition from the Maoist legacy of guerrilla warfare to current military concerns (i.e., local warfare, border incidents, etc.) AMS also assists the CMC and GSD with high-level direction in army building [redacted]

[redacted]

(2) [redacted]

(3) (U) AMS is currently organizing a large number of research personnel in a renewed effort to conduct intensive studies of modern scientific and technical knowledge. The academy is importing and applying new research methods as well as improving the quality of its research personnel and products. New facilities for MOR and for military command automation research are also being constructed. There are numerous complicated problems confronting the PLA as a result of the changes in the world's strategic patterns and rapid scientific and technical developments; AMS helps by serving as a "think tank" to improve defense strategies, army building, and predictive research on important issues of future warfare. To accomplish this, the academy is applying methods such as cybernetics, systematology, information science, mathematics, and automation in its research in simulated operations, command automation, man-machine interface, and military data banks. Over 1000 strategic, campaign and tactical research models, simulation systems, and special models have already been established by AMS to assist in its research work.

(u)

(4) [redacted] AMS comprises three institutes: the Military OR and Analysis Institute (MORAI), the Political Work Research Institute, and the Mao Zedong Military Thought Research Institute. MORAI originated as a five-man group studying MOR

and systems analysis at AMS during the 1970s. By 1980, the group had expanded to become the Combat OR and Analysis Department, the first OR office in the PLA. In June 1986, they became MORAI.

(5) [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

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(6) [redacted] Much of MORAI's work may be done on a contract basis, and the institute responds not only to the PLA GSD's requests but also to the military regions (MR). [redacted] The institute may also do some modeling work for nonmilitary organizations on a commercial basis.

d. NDU (U).

(1) [redacted]

(2) [redacted] Researchers at the NDU have developed their own software and models to simulate combat, combat support functions, AD, naval, and general defense. [redacted]

(3) [redacted]

(1)(d) 5USC552

e. [redacted] Chinese Systems Engineering Society (CSES) (U). In 1980, the CSES was established with Qian Xuesen as chairman. The society appears to be composed of representatives from civilian and military R&D, scientific, academic, and industrial circles. [redacted]

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(U)

f. [redacted]ommittee of Military Systems Engineering (MSE) (U). In 1981 the Committee of MSE of CSES was established to promote research. The committee's host agency is MORAI. The committee comprises more than 60 member organizations, including

AMS, military academies, the "General Departments," and service and defense ministry research institutes. Committee members are appointed by and funds are provided by member organizations. The committee holds an annual conference, convenes seminars, and publishes books and magazines on the application of MOR, software, wargaming, and the prediction of future strategy.

g. [redacted] Society for MOR (U). [redacted]

h. (U) Military Science and Technology Association (U). The Chinese Military Science and Technology Association was formed in 1991 as the first academic group of the entire military forces. The association serves as a military and academic research organization of the general public to exchange and spread the results of military and scientific research activities, to develop international exchange in military and academic areas, to encourage academic ties with foreign research organizations and researchers, and to organize activities to evaluate and recognize the results of academic research. Although no specific influence by this association on China's MOR efforts can be identified, the participation of key personalities from AMS, BISE, and other influential MOR-related groups indicates the potential influence of this association on Chinese research efforts.

i. (U) Chinese Society of Military Future Studies (CSMFS). AMS, COSTIND, NDU, and the MR commands participate in the CSMFS. This group discusses trends in development of military technology, characteristics of modern war, the relationship between future wars and high-technology weapon development, and China's strategy for high-technology weapon development.

3. Chinese Philosophy Toward Use of MOR (U)

a. (U) Until the mid-1980s qualitative study was the only research method applied to Chinese strategic analysis. AMS conducted a symposium in 1986 on defense strategy and systems engineering to the year 2000. As a result of this symposium military system engineering institutes began to turn their attention to macro-decision-level analyses that combined quantitative and qualitative research. Analyses have predominantly focused on defense budget allocation, force structures, and the prediction through computer wargaming of international conflicts taking place around China.

b. (U) The introduction of quantitative methods for strategic analyses led to an ongoing debate on the use and balance of quantitative and qualitative analyses. This debate is not unique to the Chinese; military strategists and wargamers in the United States have had the same ongoing debate. A discussion meeting at the Army Command College in 1987 determined that quantitative analysis methods should be given the full attention of military planners and decisionmakers and be organically combined with qualitative analysis. In effect, quantitative methods should be used on problems that can be quantified. However, military personnel's intuition and experiences or other qualitative methods should be used to solve problems for which numerical analysis is impossible, such as improvements in command methodology and troop morale. Systems engineering tools were to be used to combine qualitative and quantitative analyses.

c. (U) Despite this resolution in approach, the issue seems to have continued. As recently as 1990 a Liberation Army Daily article restated the problem and the solution. The article stated that computers can be used to represent the relative strengths of opposing military forces, the area of the battlefield, enemy and friendly losses, war material consumed or captured, and other factors that can be reduced to numerical quantities. However, many key factors cannot be represented on a computer, such as the application of various strategies, the commander's experience, and the quality of opposing forces, especially the "mental quality" of the soldiers.

Efforts have been made to assign numerical values to these factors, but the scores are generally random and unscientific. Chinese military strategists have tended to exaggerate the role of the computer in studying military strategy. The article concluded by saying that in the study of military strategy, the computer must be used in a supporting role and not as a substitute for the human brain.

4. Summary (U)

(U) Chinese military science researchers were quick to adopt advanced scientific means and methods employed in MOR during the 1980s. These methods contributed to quantification of research work, automated information processing, simulated testing and training, scientific forecasting, and decision making. Numerous institutes were established or realigned to initiate and coordinate MOR developments within the PLA. MOR-related organizations and societies were also established to encourage an exchange of information within the MOR community domestically and internationally. Despite concerns over quantitative-vs.-qualitative analysis, high-level commanders accepted and began to use software science to solve complex military problems, conduct research, and determine national defense policies. Chinese objectives for MOR and system analysis include the following:

- Demonstrate combat capabilities of weapons; evaluate weapons; and create simulation models to demonstrate the operational effectiveness of antitank weapons, air-to-air and air-to-ground combat, and AD warfare.
- In tactics, study the allocation of fire, the introduction of submarines to the fleet, etc.
- Devise modeling and methodology for wargaming, improving the techniques used for electronic-warfare simulation, attrition, microcomputers, etc.
- Conduct strategic studies in energy-based theories, national defense spending in the year 2000, etc.

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SECTION II

CHINESE MILITARY OPERATIONS RESEARCH PRODUCTS (U)

(U) MOR and systems-engineering techniques have been applied to problems ranging from system design to macro-level decisionmaking in China. Computer-based models have been used to assist in weapon development and evaluation as well as operational studies, logistics, training, and decisionmaking. The use of TES, or computer wargames, and training simulators have proved to be one of the best and most cost-effective methods for training and have become an important part of China's efforts at modernization. Centers and laboratories for the development and use of simulators have been established by most branches of the PLA. This section briefly discusses some mathematical methods employed in China's TES, training simulators, military simulation centers and laboratories, and examples of OR applied to macro-level policies and decisions. Military-related simulation systems and developers identified in research for this study are listed in the appendix and should be used as a reference for this discussion.

A. TACTICAL ENGAGEMENT SIMULATIONS (U)

[redacted] As early as 1983, MSE techniques were being used to simulate combat and predict the outcome of combat simulations. [redacted]

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1. Methods (U)

a. (U) Introduction (U). The most popular methods employed in TES in China are Lanchester equations, efficiency indices, and Monte Carlo techniques. Efficiency indices are used in most high-level models; lower level models (probably division and below) employ Lanchester equations. Monte Carlo techniques are used at all levels of modeling. Other techniques employed in Chinese models and analyses include probability theory, linear programming, nonlinear programming, game theory, queuing theory, and regression analysis.

b. (U) Lanchester Equations (U). The Lanchester equations, differential equations to show the rate of change of each force with respect to time, were developed in 1914 and are considered to be the first attempt to establish a mathematical model of mass combat. The following assumptions are implicit in the Lanchester equations and reflect the simplistic nature of the approach:

- Each unit is within range of all enemy units and kill probability is not a function of range.
- No provisions are made for movement, retreat, or advance.
- All units involved on each side are identical.
- Engagements continue until one side is wiped out.
- Odds of winning are not given as a function of the variables.

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c. (U) Indices of Efficiency (U). The index of efficiency is a measure of success in accomplishing an objective. Indices are often used in weapon-system analysis, force-strength estimation, cost-effectiveness analysis, and combat-effectiveness evaluation. The method, sometimes referred to as combat power

scores, was first accepted by the US Army and later applied by the PLA to military quantitative analysis in the mid-1980s. A number of models based on efficiency indices have been developed. The method is sometimes combined with the Lanchester equations.

d. <u>(U) Monte Carlo Techniques (U)</u>. Monte Carlo techniques employ random sampling to obtain an approximate solution to a problem. These methods are often used in simulations to determine effectiveness criteria and are popular in Chinese tactical or theater-level combat models.

e. [redacted] <u>AI and Expert Systems (U)</u>. [redacted]

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f. <u>Nonlinear Systems (U)</u>.

(1) (U) A surprising example of Chinese research in an area only recently developed in the West is nonlinear systems. A 1989 military textbook, <u>Modern Scientific Methodologies and Their Military Applications</u>, discussed dissipative structures, synergetics (or complexity), and catastrophe theory. Research in these areas is applicable to improving wargaming capabilities, cost and operational effectiveness analysis, and quantification of combat potential of forces.

(2) (U) A dissipative structure is a geometrical object that forms as a specific nonlinearly interacting system undergoes time evolution. According to the aforementioned textbook, military units are considered complex systems capable of exhibiting dissipative structures. Therefore, the nonlinear interactions between units must be considered in any force analysis or modeling.

(3) (U) According to this textbook, synergetics is a discipline that synthesizes and summarizes the universal rules that emerge from the study of time evolution of large numbers of independently organized nonlinear systems. The term synergetics, which is usually called complexity in the West, was coined by the German researcher Haken in the 1960s. Haken's work is referenced several times in the textbook's discussion of synergetics, indicating its use by the Chinese in the development of the area. The text goes on to discuss the importance of synergetics in determining the effects of changes in weapon technology on combat, especially with the increased use of combined-arms techniques and high-speed variations on the battlefield. Synergetics is also important in quantitative analyses of battlefield situations and forecasting.

(4) (U) Catastrophe theory, or the study of static solutions to nonlinearly interacting systems, can be viewed as an extension of the nonlinear Lanchester equations, which are used to represent indirect firing. (The linear Lanchester equations also exhibit nonlinear behavior given certain conditions.) Therefore, catastrophe theory is also important in TES and combat modeling.

(5) (U) No evidence of the employment of these methods in Chinese wargames or simulations has been identified to date; however, their inclusion in a military textbook indicates that Chinese knowledge and level of research in the area is near or at the state-of-the-art.

2. <u>Simulations (U)</u>

a. [redacted]

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[redacted]

b. (U) The three models displayed during the demonstration were the Quick Model III, Yangtze River 2, and the Army Hierarchical Combat and Command Simulation System (AHICCSS). A brief description of these models is given below, followed by a description of two more recently developed tactical simulation models.

(1) <u>QUICK MODEL III (U)</u>.

(a) (U) QUICK MODEL III, developed by MORAI around 1986, is used for training corps, division, and regiment commanders and their staffs in decision making and tactics. The model simulates an exercise between Red (PLA) and Blue forces. Commanders direct the movement of their units and control the development of engagements. The model uses the index method to assist in the evaluation of new tactical concepts.

(b) (U) The system is based on IBM-PC or Great Wall 0520 computers (the Chinese equivalent) and graphic displays connected by a local area network, as shown in figure 3. This equipment configuration is probably the AMS-developed 5218 combat simulation display system. The 5218 system has workstations for the Red army, the Blue army, and the director. Each workstation has an independent display (1024x1024 pixels) and a Chinese-character format display. The system includes military coordinate mapping and dynamic displays of the forces and their movements.

(2) <u>Yangtze River 2 (U)</u>.

(a) (U) Yangtze River 2, also known as Chiangjiang 2, was developed about 1985 and simulates offensive and defensive warfare at a division or regimental level. This was the PLA's first computer-based division-level model. It can be used for comparisons of battles, verification of military science concepts in division tactics, and training of commanders. The largest unit the model can support is a reinforced army division; the smallest, two battalions.

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(b) (U) The system configuration is shown in figure 4. The model is consists of three modules: input module, simulation module, and output module. The input module processes the users commands and forwards them to the simulation module, the heart of the model. The simulation module is composed of the following submodules: command and control, movement, attrition calculation (using Lanchester equations) for nuclear/chemical weapons and artillery, and attrition calculation for air/land combat. The output module transforms the results of the simulation to statistical data, which is presented in a table. The graphic displays are controlled by the simulation module.

(c) (U) The model is written in FORTRAN and runs on an UN-68 super minicomputer or IBM PC/AT. Each execution requires approximately 1 week for data organization and preparation and 3 to 4 hours to run.

(3) <u>(U) AHICCSS (U)</u>. AHICCSS runs on an Apollo DOMAIN DN550 or equivalent workstation. The system was developed by MORAI around 1987 and is used in tactical research. AHICCSS is composed of four functional subsystems (fig 5): combat model, graphics, database, and knowledge processing. The combat model consists of two modules: command, control, communications, and intelligence (C^3I) and battlefield. The C^3I module describes the decision-making processes of preparations and operations. The battlefield module is divided

into at least seven submodules for handling forces: movement, nuclear attack, chemical warfare, artillery fire, air/land and land/air attack, land combat, and logistics. This model combines the use of combat power scores with Lanchester equations.

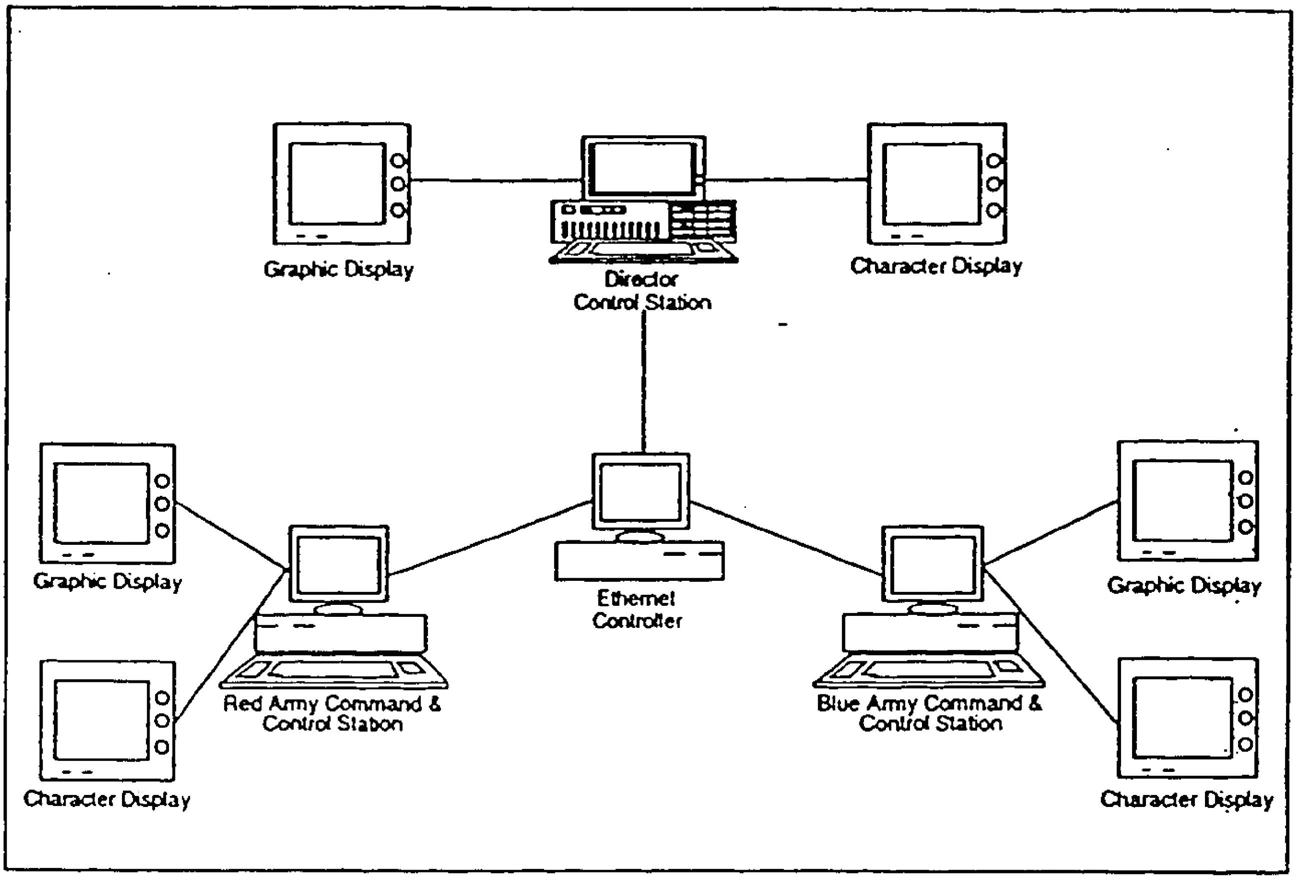

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Figure 3. (U) Equipment Configuration for QUICK MODEL III TES

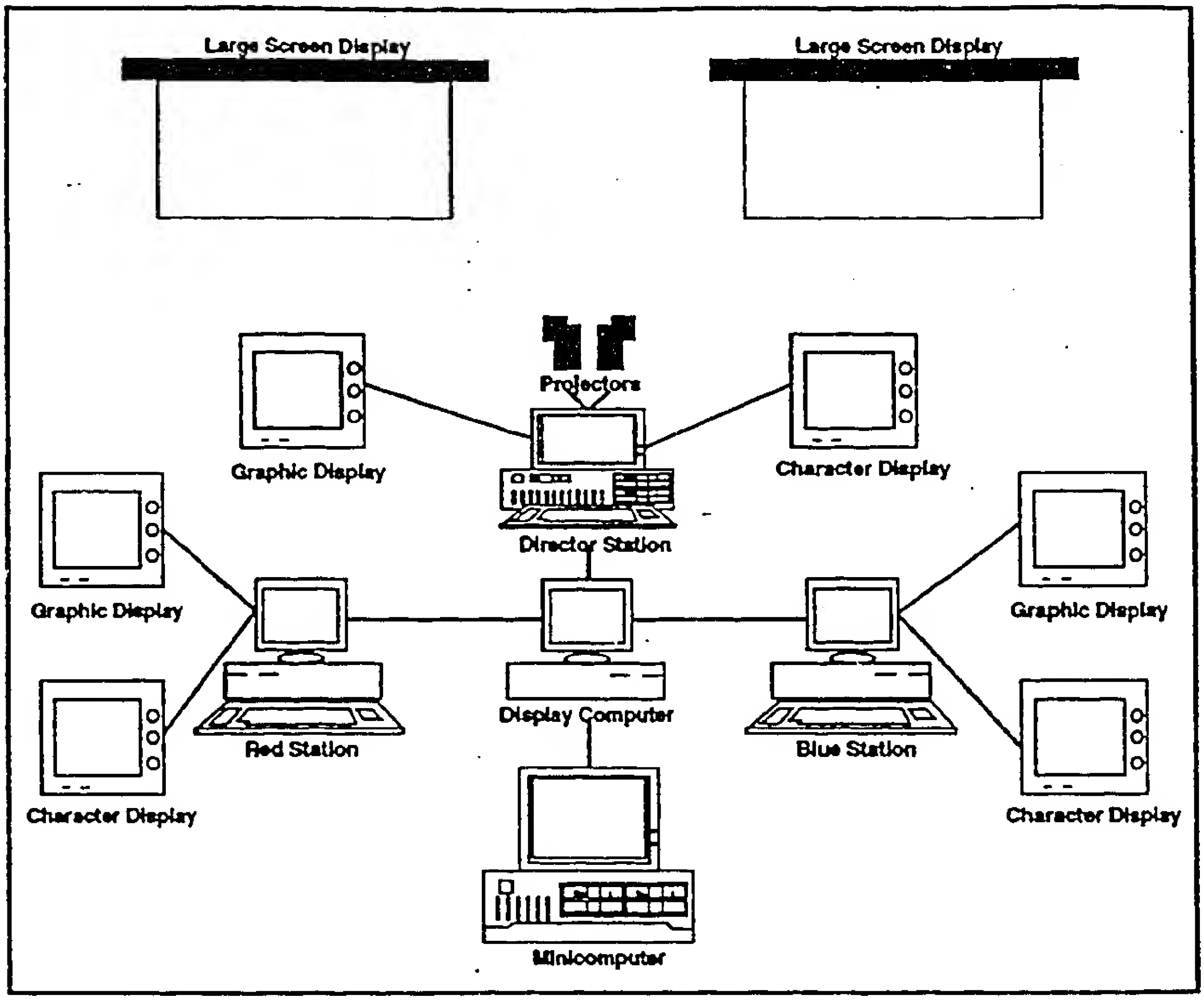

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Figure 4. (U) System Configuration for Yangtze River 2 TES.

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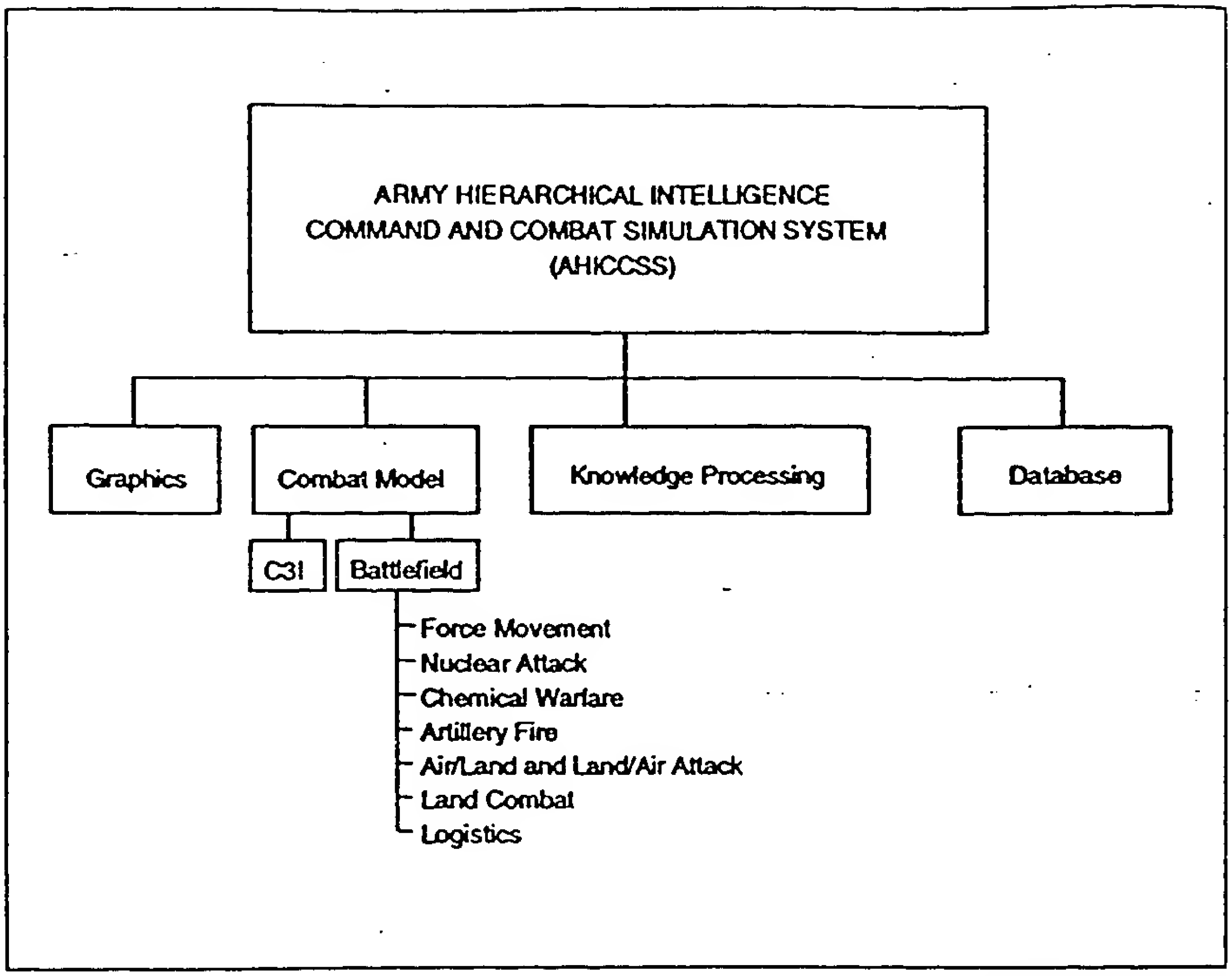

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Figure 5. (U) AHICCSS Subsystems and Modules

(4) [redacted] Counter-Operation Training Simulation System (U). A 6-year project to develop a simulation system for counter-operation training between combined-arms units was completed in 1992. The system was developed under the guidance of the GSD and with the cooperation of AMS. [redacted]

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[redacted]

3. Summary (U)

a. [redacted] China's early efforts at TES were typically organized in a modular structure and were intended for use by certain cadres. A typical simulation system might be written in FORTRAN and executed on IBM PC/AT computers connected by a local-area network. A simulation might take several hours to execute [redacted] The simulations are executed in real time, often with enhanced audio-visual aids such as large-screen displays. The models are written in more advanced programming languages than their predecessors (e.g., Turbo C, Turbo Prolog, and Ada) and utilize expert systems and AI.

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b. [redacted]

B. TRAINING SIMULATORS (U)

4. Background (U)

a. (U) Chinese ground forces began an aggressive program to develop advanced training simulators in 1984. The navy, air force, and 2d Artillery quickly followed their lead with similar programs. These programs initiated the first phase (1984-87) of GSD's plan to develop training simulation systems and integrate them into all aspects of PLA training with a complete training system developed by 1993. Each service has rapidly moved ahead with simulators designed to cover all aspects of its individual combat responsibilities. In 1985, the Chinese conducted a tactical confrontation exercise involving ground and air units and employing a number of simulators. Similar exercises were conducted by the air force in 1986 and the navy in 1987. Between 1985 and 1987 simulator design advanced from tactical training simulators to strategic training simulators, including a computerized campaign operations command simulation system for training in decision making.

b. (U) The second phase of GSD's plan (1987-89) focused on integrating individual simulations into larger organic systems and consolidating the development of simulators throughout the services. However, by the end of the second phase, over 30 000 training simulators of 450 varieties had been developed for use in unit training and at PLA institutes and colleges. This apparent overabundance of simulators resulted in an extensive amount of duplication of effort. This is particularly evident in the large number of navy and air force command-and-control systems, the proliferation of navy navigation simulators and air force flight simulators, and armor tank training simulators. Despite the efforts of GSD, units continued to build their own simulators, with no apparent coordination with the general headquarters.

c. (U) The following sections provide a brief description of the training simulators in use by the Chinese ground forces, air force, navy and 2d artillery. Specific details on the simulators are not available. They are presented here to show the breadth of application for training simulators within the PLA and China's commitment to their use.

5. Ground Forces (U)

a. (U) By 1987, at least 27 laser and electronic simulators, for various combat systems had been developed by PLA institutions and ground-force units. The ground

forces currently have training simulators for the following areas: command and control, armor, artillery, engineer, nuclear and chemical warfare, and radar training. Figure 6 shows the types of ground-force simulators and examples for each.

b. (U) The command-and-control simulators include campaign simulation systems that can simulate various tactical confrontations. Some simulations include aspects of logistics, data and information processing and display, as well as decision-making support for commanders and their staffs. The tactical simulations may include simulators for training in tactical communications, target tracking, or electromagnetic-pulse protection.

c. (U) Training simulators for armor units include tank and antitank training simulators. More than 21 kinds of tank training simulators have been developed and are used to simulate tanks, electrically driven tanks, tank driving, tank electrical circuits, etc. Obviously tank-training simulators have been one of the areas where lack of standardization and coordination have resulted in duplications in effort and a plethora of systems.

d. (U) The antitank simulators cover training for antitank missile and artillery gun firing, as well as simulating the effects of antitank mines on armor.

e. (U) The artillery trainers include field and antiaircraft artillery (AAA). Artillery moving targets are also simulated for training in reconnaissance, combined-arms maneuvers, tactical exercises, and live-fire training. Field artillery trainers include gun simulators and meteorological forecasting in support of artillery.

f. (U) AAA simulators can simulate the AAA battlefield environment, can assist in training gun firing and communications, and can help with the integration of AAA with ground-combat operations.

5 USC 552 (b) (1)

g. (U) There are engineer training simulators for driving, communications, and technical support as well as land-mine simulators.

h. (U) In the area of nuclear and chemical warfare, simulators have been developed to simulate a chemical attack and the effects of a nuclear explosion.

i. (U) Training simulators developed for radar operations include those for target searching and tracking under various clutter conditions.

6. Air Force (U)

a. [redacted] By the end of 1987 the air force had developed six major simulator systems, primarily for command-and-control training areas. In recent years, simulator development has increased rapidly. Development activities have been conducted chiefly for individual units or military institutions. [redacted]

b. (U) In addition to the command-and-control simulators, current training simulators include flight training, bombing and missile firing, and radar simulators (see fig 7).

c. (U) The air force's command-and-control simulators can simulate different battlefield conditions with various combat aspects, including flying formations, airfields, radars, antiaircraft gun emplacements, and surface-to-air missile (SAM) positions. Some of the simulations allow for variations in flight tactics, optimization of combat plans, and simulated battles.

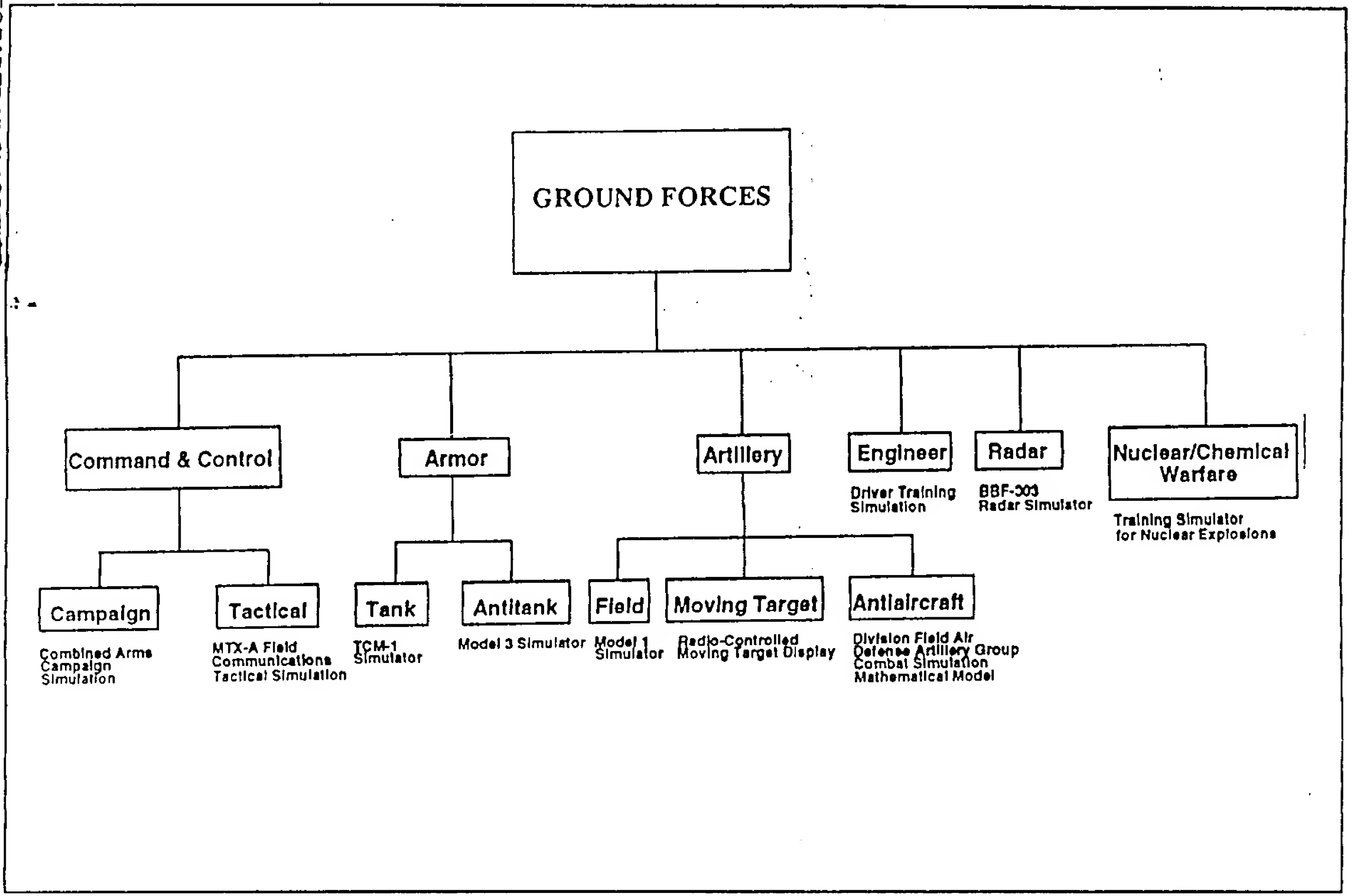

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Figure 6. (U) Ground-Force Training Simulator Areas and Examples.

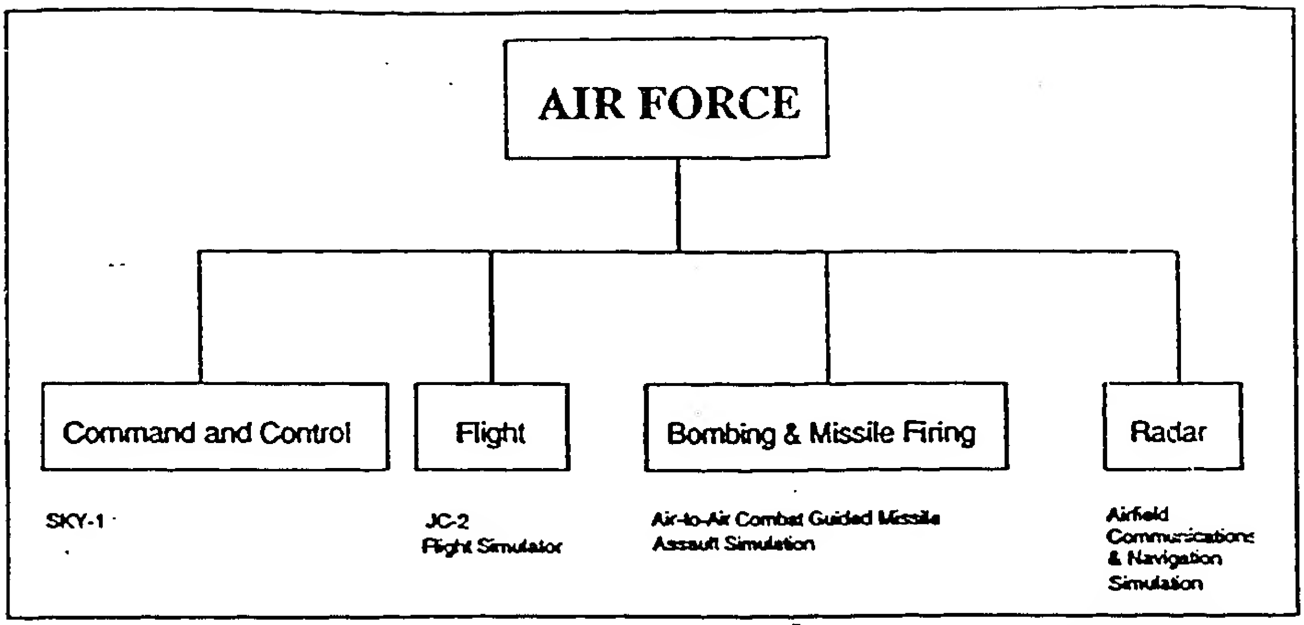

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Figure 7. (U) Air Force Training Simulator Areas and Examples.

d. (U) Since 1989, the air force has had a series of flight simulators for all types of combat aircraft. Among the 16 flight simulators in the inventory are flight simulators for fighter interceptors, attack fighters, and long-range bombers. The flight simulators afford training in day-and-night spiral maneuvers, stunt flying, and flight and attack formations. Laser and electronic simulators are used for air-to-air and air-to-surface combat.

e. (U) With the development in 1992 of the "Simulation System Applied to Three Types of Airborne Platforms," which simulates aerial combat between target drones, attack fighters and air-to-air missiles, the Chinese press claimed that the air force now produced the most advanced flight simulators in the world. Following this achievement, China produced in 1993 a three-dimensional (3-D) system with a digitally simulated cockpit, six degree-of-freedom platform, and 3-D vision. Despite these recent advances, Chinese flight simulators are assessed to be comparable to 1980s-vintage Western flight simulators.

f. (U) The training simulators for air force bombing and missile firing include laser simulators for aerial targets and long-range firing. Some also simulate displays of firing and bombing effects, transmission of target-range information, targets, and landmark, radio, or integrated navigation.

g. (U) The air force radar training simulators simulate different air situations and air exercises for operators. Others are used for navigation, electronic countermeasure, or flight-plotting training.

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h. [redacted]

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7. Navy (U)

a. (U) By 1987, the navy had developed at least nine major simulation systems for training. They fell into the following five categories: command and control; warship, torpedo, and missile attack; radar and navigation; submarine; and naval air force and AD simulators. See figure 8.

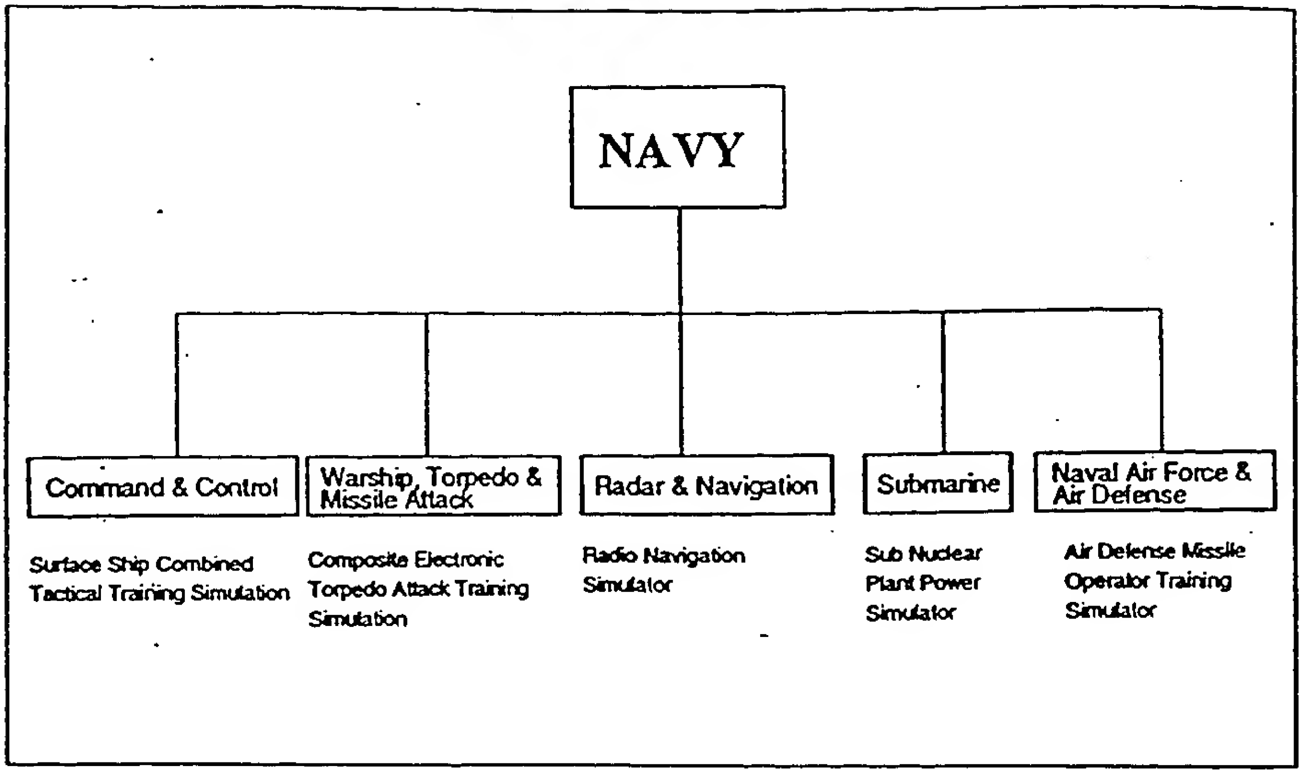

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Figure 8. (U) Navy Training Simulator Areas.

b. (U) The command-and-control systems cover various aspects of campaign operations including command and decision-level skills for tactical- and campaign-level operations.

c. (U) Training simulators for warship, torpedo, and missile attack may include one or more of the following features: analysis of target hits, summary of torpedo track, and simulation of missile targets.

d. (U) The radar and navigation training simulators simulate collision situations and/or other aspects of navigation for ship-steering training.

e. (U) By 1989 the Naval Submarine Academy had developed 11 types of simulators for training in sonar, radio operations, submarine tactics, submarine nuclear powerplant, torpedo assault, and navigation.

f. (U) The naval air force and AD simulators provide training in flight simulations and firing of AD missiles. Other simulators simulate diesel-engine technical problems and the acoustical ocean environment and underwater targets.

g. [redacted]

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8. <u>2d Artillery Corps (U)</u>

a. (U) By 1989 the 2d Artillery Corps had built 117 simulation systems of 24 varieties for training launch battalions and guided-missile brigades. The corps also possesses a complete range of simulators for specialized training of personnel operating all types of PLA guided-missile systems.

b. (U) The command-and-control training simulators of the 2d Artillery Corps typically simulate the processes associated with a guided-missile test launch and related problems.

c. (U) Other training simulation systems (see fig 9) provide training for guided-missile-unit launches, with emphasis on decision making, launch preparations, and guided-missile flight simulations. The guided-missile flight simulations include simulations of the core operations of the missile and platform and real-time simulations of launches using 3-D graphics.

9. <u>Summary (U)</u>

a. (U) The reduction in China's defense budget as a percentage of the state budget during the 1980s resulted in an emphasis on the development and effective use of training simulators for economic reasons. Additionally, the use of simulators in military training has provided scientific figures for improving weaponry, equipment, and command style. Major developments in PLA training simulators have been featured prominently in the Chinese media as important contributions to the combat readiness and modernization of China's defensive forces.

b. (U) Many of the Chinese-developed training simulators are also used for parameter studies and system and operational analysis. China claims to have been the first country to develop a chemical-defense training/operation system and one of a few countries to have a campaign simulation training system.

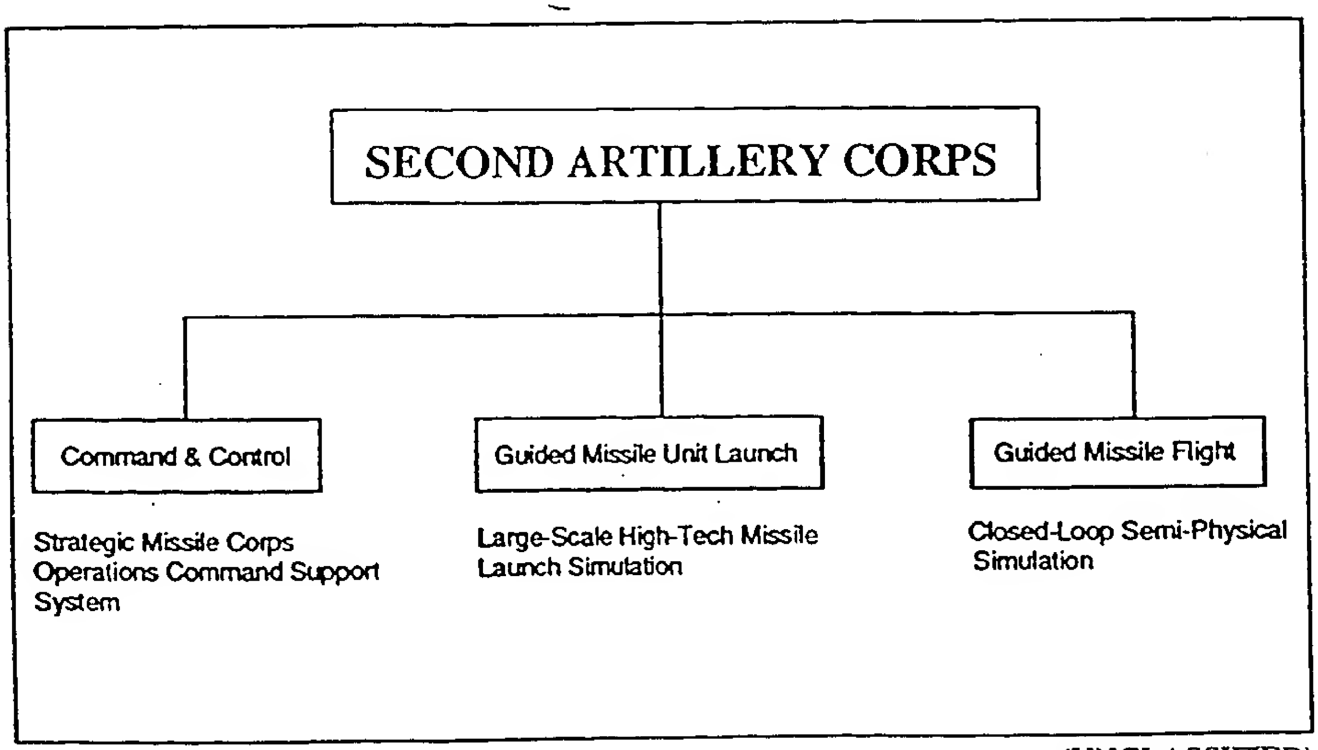

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Figure 9. (U) 2d Artillery Training Simulators and Examples.

c. (U) The Chinese are certainly enthusiastic about the development and use of training simulators. However, the lack of management for this enthusiasm has resulted in uncontrolled proliferation and duplication of simulators within the PLA. In order to maximize the benefits afforded by training simulators and to accomplish its goal of having a complete training system with a military-wide network linking operational training simulators, the PLA must implement a management structure that does the following:

- Promotes the initiative found within the MR and military units to continue developing simulators.
- Prevents duplication by tracking the development of new simulators and promoting their use throughout the PLA.
- Standardizes the use of simulators.

Earlier efforts by the GSD to do these things have failed, except for the 2d Artillery Corps. Corps headquarters appears to have been somewhat successful in controlling the development of simulators and standardizing simulation systems.

d. [redacted]

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C. DEFENSE STRATEGY AND POLICY PROJECTS (U)

10. Year 2000 Study (U)

a. [redacted]

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[redacted]

b. [redacted]

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11. Nuclear Disarmament Model (U)

[redacted]

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12. Others (U)

a. (U) In the area of military and strategic planning, the GSD Engineering Department used systems theory and OR

methods to develop a model to determine the strategic value of individual cities and a "quantified systems analysis model" to determine the likelihood of enemy attack directed at these cities.

b. (U) A model using system network theory was researched for application in viewing attack strategies against enemy forces and campaign implementation sequences. This included the optimum-path determination for enemy force suppression.

c. (U) Quantitative methods have also been used to analyze attacks, bombing, and aviation troop strength as an aid in decision making.

d. [redacted]

e. [redacted]

f. [redacted]

g. [redacted]

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D. SIMULATION CENTERS AND LABORATORIES (U)

13. Background (U)

(U)

a. [redacted] Since the early 1980s, China has established many simulation centers and laboratories in the military, industrial, and academic sectors to support modeling and simulation efforts. The creation of simulation centers and laboratories in these different sectors indicates China's commitment to and reliance on simulation for modernization.

b. [redacted]

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14. Wargaming Centers (U)

[redacted]

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15. Sanjie Training Center (U)

a. (U) The Sanjie Training Center, the first combined tactical training center of the PLA, was activated in the Nanjing MR in April 1986. Second-phase construction began in 1988, and the center was scheduled for completion in 1990. The center trains regimental and higher echelon units in combined-arms training. The center consists of five major systems: a computerized tactical simulation system, a laser/electronic confrontation system, a battlefield monitoring system, a drone and target system, and an information transmission system. The center possesses a microwave communications tower, covers 180 km^2, and can accommodate 3 to 4 complete divisions on maneuvers and 8 to 10 division

headquarters practicing simulated confrontation exercises annually.

b. (U) The training center is considered to be an experimental project, based on training centers built by foreign armed forces. Its main tasks include:

- Test and assess unit combined tactics. (This includes the use of "sophisticated equipment" in plan optimizing, decision making, and evaluating and umpiring.)
- Study new techniques of combined tactical training.
- Prove new equipment and training aids.

The expert systems developed by the NDUST and previously discussed are intended for application at the center.

16. Armored Forces Engineering College (U)

(U) The Armored Forces Engineering College is equipped with the PLA's first modern armored force simulator training center. The center is located in a building at least three stories tall. Various types of terrain mockups and a few tank simulators have been installed on the first floor of the building. The second floor houses the firing simulator room, while the third floor houses the communications simulator room.

17. 2d Artillery Command (U)

[redacted] The 2d Artillery Command Academy's simulated tactical training center consists of four computerized parts: a simulated tactical training system, a simulated combined-arms tactical training system, a communications training system, and an engineering training system. [redacted]

[redacted]

18. Navy Simulation Centers and Laboratories (U)

a. (U) Navy Simulation Submarine Attack Training Laboratory (U). The Navy Simulation Submarine Attack Training Laboratory, a subordinate element of the Naval Submarine Academy, contains simulated periscopes, video cameras, and devices for depicting targets, target distances, angles, and position control. Students can practice dealing with a simultaneous torpedo attack by two vessels against the same or different targets. Submarine commanders may use the laboratory's equipment to simulate attacks on another submarine, a surface vessel, or a helicopter. The laboratory is also being used for research in submarine tactics and in the employment of torpedoes, missiles, and mines.

b. (U) Navy Submarine Tactical Simulator Manipulation Laboratory (U). The Navy's Submarine Tactical Simulator Manipulation Laboratory was established by the Naval Submarine Academy. The facility consists of 22 special classrooms where the major functions and operating skills required on a maritime battlefield can be simulated or practiced. The laboratory has a special submarine command classroom, which simulates Red and Blue forces. The classroom provides commanders with an all-position offensive and defensive training ground with arbitrary combat modes.

c. (U) Naval Combat Simulation Training Center (U). The Naval Combat Simulation Training Center equipment includes the Ocean Combat Simulation Training System. This system combines the use of computers, communications networks, image display, time control, quantity optimization, man and machine exchangeability, and artificial knowledge.

19. Ministry of Aerospace Simulation Centers (U)

a. Beijing Simulation Center (U).

(1) (U) Construction on the Beijing Simulation Center was completed in 1993. The center, under the Ministry of Aerospace, was begun in 1984 and is assessed to be the laboratory used by the ministry's Second Academy (also known as the Changfeng Science and Technology Corporation). The Second Academy is responsible for SAM developments.

(2) (U) China claims that the Beijing Simulation Center is the world's largest simulation center. The center's reported mission is assimilation of new imported technologies, avoidance of mistakes in real-time operations, and economical development of new technologies. The center is composed of at least 11 laboratories, including a radiofrequency-guidance simulation laboratory for homing missiles. This laboratory claims to be the world's first combined millimeter-wave and microwave laboratory.

(3) (U) Foreign researchers are permitted to work at the center, as it actively pursues simulation-related business in communications, energy resources, chemical engineering, and other civil system engineering areas.

b. <u>Third Academy's Simulation Center (C).</u>

(1) [redacted]

(2) [redacted] A Third Academy simulation company, called TRAMAS, has opened an office in San Francisco. [redacted]

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E. SUMMARY (U)

20. <u>Commitment to OR Methods Shown by Advances in the Last Decade (U)</u>

a. [redacted] Chinese commitment to military science, particularly OR methods, is evidenced by the rapid advances made in modeling and simulation from the early 1980s to the present. TES advanced from simple workstation environments to expert systems; the Chinese goal is to develop large distributed networked systems. Training simulators are available not only for military training but also for use in aviation, space, chemical, and electrical power. [redacted]

b. [redacted]

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21. <u>Impact (U)</u>

(U) MOR is providing military and political leaders assistance in policy making and determining the direction and growth of the PLA, which is certainly a dramatic change from pre-1980 times. TES and training simulations are producing better-trained soldiers and commanders. Weapon system simulators are also resulting in reduced equipment and development costs. Simulation centers and laboratories, some at world-class

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levels, have been constructed, and foreign investment is actively being pursued. China's commitment to MOR and simulation efforts certainly indicates its intentions to be a leader in simulation and simulator technology. The use of simulators has also been an important factor in China's modernization efforts.

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SECTION III

EXTERNAL INFLUENCES ON CHINESE MILITARY OPERATIONS RESEARCH (U)

1. General (U)

a. [redacted] Although China's history in MOR dates back to the days of Sun Tzu, many of China's developments in MOR can be attributed to influences from other countries, particularly the United States and the FSU. [redacted]

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b. [redacted]

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2. United States (U)

a. [redacted]cademic Exchanges and Conferences (U). The first substantive contact between the MOR and systems analysis communities of the United States and China occurred in 1987 when a US MOR delegation, led by the Deputy Under Secretary of the Army for OR, visited China to participate in the first "China/US Seminar on Methodologies in Defense Systems Analysis." [redacted]

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b. Organizations and Programs Used as Models (U).

(1) [redacted]

5USC552 (b) (1)

(2) [redacted]

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[redacted]

(3) ([redacted]) [redacted]

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(4) ([redacted]) [redacted]

(5) (U) Chinese scientists have studied AMIP's philosophy and noted the statement by two US researchers, J. D. Robinson and H. K. Fallin, that "model management and configuration control on an agency by agency basis leads to proliferation of incompatible models." As a result, the Chinese have tried to follow this philosophy in their model developments and have attempted to develop hierarchical models not only with a one-to-one correspondence with the military hierarchy but also with unique Chinese characteristics. One of BISE's roles in the OR communities is to apply this philosophy to Chinese model and simulation efforts. However, given the proliferation of models, particularly training simulators, in China, BISE has had little success in controlling development.

(6) (U) Although the US military has been a primary model for the Chinese in the area of simulations and automation, Chinese interest increased significantly after the Gulf War because of the performance of high-technology weapons during the war. Reports that the US Air Force's operational bombing plan had been tested in the Air Force's zone-attack model and that the Pentagon had used a computerized decision-making support system (including a joint operational planning system, joint zone model, and an emergency analysis model) to carry out exercises in task analysis, planning and relaying of instructions, situation assessments, and plan formulation highlighted the importance of automation and simulation in modern warfare.

(7) ([redacted]) [redacted]

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c. ([redacted]) US/China Joint Ventures and Cooperative Research (U).

[redacted]

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(1) DMSI (U).

(a) [redacted]

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(b) [redacted]

(c) [redacted]

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(d) [redacted]

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[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

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(c) [redacted]

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(2) Rand Corporation (U).

(a) [redacted]

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(b) [redacted]

(3) Others (U).

(a) ([redacted])

(b) [redacted]

(c) (C[redacted]

3. Former Soviet Union (U)

a. (u) [redacted] The FSU has been another source of OR training and information, especially during China's early years in the field. Many Chinese researchers studied modeling and simulation at Soviet institutes during the 1950s and 1960s. Two books believed to have had a profound effect on Chinese MOR studies were written by Venttsel and Tsuyev, respectively, and translated into Chinese between 1974 and 1976.

b. [redacted]

c. (U) A recent visit to the Beijing Simulation Center by the First Vice Chairman of the Ministerial Council of the FSU and a leading missile design engineer may result in a joint venture between China and the FSU. The visitors were impressed by the center and, according to the Chinese press, stated that its missile manufacturing laboratory is 10 years ahead of that of the FSU and the SAM laboratory is at least 5 years ahead of counterpart FSU facilities.

4. Japan (U)

a. [redacted]

b. [redacted]NF) [redacted]

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5. Technology Imports (U)

a. (S-[redacted]) [redacted]

b. [redacted]

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c. [redacted] China has also purchased flight simulators from foreign companies such as CAE Electronics of Canada and Alcatel of France, reportedly for commercial pilot training. [redacted]

[redacted]

d. [redacted]

e. [redacted]

6. Summary (U)

a. [redacted]

b. [redacted]

[redacted]

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[redacted]

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SECTION IV

FUTURE OF MILITARY OPERATIONS RESEARCH IN CHINA (U)

1. Current Status (U)

[redacted]

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2. Future Research Efforts and Developments (U)

a. [redacted] Introduction (U) [redacted]

b. (S[redacted]New Projects (U). [redacted]

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(1) (S[redacted]AI computer (U). [redacted]

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[redacted]

(2) (S[redacted]). [redacted]

- [redacted]
- [redacted]
- [redacted]
- I[redacted]

c. (S-[redacted]University for Simulation Technology (U). [redacted]

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[redacted]

d. (U) Other Areas (U). Based on papers presented at the 2d Beijing International Conference on System Simulation and Scientific Computing in October 1992, defense applications continue to be a primary focus of Chinese simulation research. Key among these are simulations involving aircraft, ship, missile, and radar systems. Chinese researchers are addressing many of the same topics as Western researchers: simulation software, languages and environment, manufacturing and training simulators, engineering analysis, hardware simulators (real-time and simulated time), uses of advanced techniques in simulation such as neural networks, AI, expert systems, parallel processing, and distributed simulation. However, in most cases Chinese developments have not yet reached the level of those in the West (often 10 to 20 years behind).

3. Limitations (U)

a. (U) The primary factor limiting China's growth in the area of MOR today and in the foreseeable future is a lack of computing power. Export restrictions imposed by the United States and other countries on the sale of advanced computers and design software to China have slowed developments in MOR. However, with the Chinese ability to copy and build foreign systems and their commitment to MOR applications, restrictions on the export of technology will not limit Chinese developments in MOR but will only extend their development time.

b. (U) An example of Chinese capabilities in copying Western computer systems prohibited from export to China is their supercomputer look-alike, known as the Galaxy All Digital Simulator II or YF-II. This computer was developed by the NDUST in Changsha. The system has applications in fields with real-time simulation requirements such as aerospace, weaponry, transportation, energy resources, and chemical engineering.

4. Summary (U)

a. (U) With China's current philosophy toward military system developments concentrating on testing and evaluating new concepts, strategies, and/or technologies in simulators and simulation systems vice fielding new, expensive systems, developments in Chinese MOR will be key indicators of China's future military structure, policy, and weapon systems.

b. (U) Although export restrictions on software and hardware will certainly slow down research work in MOR and simulations within China, the Chinese can be expected to continue to emphasize R&D of new ideas and applications. Chinese MOR applications can be expected to closely follow developments in the West, and, if restrictions on the sale of computers are lifted, China can be expected to rapidly become a world leader in the area of MOR and simulations.

APPENDIX

CHINESE MILITARY SIMULATIONS (U)

(U) Simulation models and systems developed by Chinese military organizations are listed in this appendix. The name or a descriptive title of each system identified during the research for this study is given, as is the year of its development, its developer, and a brief description. This collection is not intended to be an exhaustive listing of all military-related models and simulations in use by the Chinese, but it does indicate the breadth of Chinese efforts in MOR and areas of concentration.

(U) The appendix is organized to facilitate reading of section III of this study. Ground-force-associated models are listed first, followed by air force, navy, and 2d Artillery Corps models. The last section of the appendix lists models that are not training-based models but rather are used for TES, defense planning, forecasting, etc.

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CHINESE MILITARY SIMULATORS (U)

(SECRET [redacted]-NC-PR-OC)

Year	Developer	Model name	Description
GROUND FORCES			
		[redacted]	
[redacted]		[redacted]	[redacted]
		[redacted]	[redacted]
		[redacted]	[redacted]
[redacted]		[redacted]	[redacted]
		[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

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(SECRET-NF-WN-NC-PR-OC)

Year	Developer	Model name	Description
GROUND FORCES (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]

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5 USC 552 (b) (1)

(SECR[redacted]-WN-PR-OC)

Year	Developer	Model name	Description
GROUND FORCES (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

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5 USC 552 (b) (1)

(SECRET [redacted]-NC-PR-OC)

Year	Developer	Model name	Description
GROUND FORCES (CONTINUED)			
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

(SECRET [redacted]-OC)

Year	Developer	Model name	Description
GROUND FORCES (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(S[redacted]WN-NC-PR-OC)

Year	Developer	Model name	Description
GROUND FORCES (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECR[redacted]WN-NC-PR-OC)

Year	Developer	Model name	Description
AIR FORCE			
[redacted]		[redacted]	[redacted]
		[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECR[redacted]WN-NC-PR-OC)

Year	Developer	Model name	Description
AIR FORCE (CONTINUED)			
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5USC552 (b) (1)

DST-1820S-187-94

5 USC 552 (b) (1)

([redacted]-PR-OC)

Year	Developer	Model name	Description
AIR FORCE (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	

5 USC 552 (b) (1)

5USC552 (b) (1)

5 USC 552 (b) (1)

(SECRET [redacted] NC-PR-OC)

Year	Developer	Model name	Description
AIR FORCE (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SE[redacted]NF-WN-PR-OC)

Year	Developer	Model name	Description
AIR FORCE (CONTINUED)			
[redacted]			
[redacted]			
[redacted]			
[redacted]			
[redacted]			
[redacted]			
[redacted]			
[redacted]			

5 USC 552 (b) (1)

5USC552 (b) (1)

5 USC 552 (b) (1)

(SEC[redacted]R-OC)

Year	Developer	Model name	Description
AIR FORCE (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
NAVY			
[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	
[redacted]		[redacted]	
		[redacted]	[redacted]

5 USC 552 (b) (1)

5USC552 (b) (1)

5 USC 552 (b) (1)

(SECR[illegible]-WN-NC-PR-OC)

Year	Developer	Model name	Description
NAVY (CONTINUED)			
		[redacted]	[redacted]
[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	
	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5USC552 (b)(1)

5 USC 552 (b) (1)

(SEC[redacted]WN-NC-PR-OC)

Year	Developer	Model name	Description
NAVY (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5USC552 (b) (1)

5 USC 552 (b) (1)

(SEC[redacted]N-NC-PR-OC)

Year	Developer	Model name	Description
NAVY (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	

5 USC 552 (b) (1)

SECRET

6USC552 (b) (1)

5 USC 552 (b) (1)

(SEC[redacted]-WN-NC-PR-OC)

Year	Developer	Model name	Description
NAVY (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	

5 USC 552 (b) (1)

SECRET

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECRET-NF-WN-NC-PR-OC)

Year	Developer	Model name	Description
NAVY (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
2D ARTILLERY CORPS			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	
	[redacted]	[redacted]	
	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECRET [redacted] -PR-OC)

Year	Developer	Model name	Description
2D ARTILLERY CORPS (CONTINUED)			
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECRET [redacted]-PR-OC)

Year	Developer	Model name	Description
2D ARTILLERY CORPS (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5USC552 (b) (1)

5 USC 552 (b) (1)

(SEC[redacted]R-OC)

Year	Developer	Model name	Description
OTHER			
		[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECRET [redacted]-PR-OC)

Yea[redacted]	Developer	Model name	Description
OTHER (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]

5 USC 552 (b) (1)

5 USC 552 (b) (1)

(SECR[redacted]-WN-NC-PR-OC)

Year	Developer	Model name	Description
OTHER (CONTINUED)			
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	

(SEC[redacted]-WN-NC-OC)

5 USC 552 (b) (1)

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LIST OF ACRONYMS

3-D	three-dimensional
AAA	antiaircraft artillery
AD	air defense
AHICCSS	Army Hierarchical Intelligence Combat and Command Simulation System
AI	artificial intelligence
AMIP	Army Model Improvement Program
AMS	Academy of Military Science
BISE	Beijing Institute of Systems Engineering
C^3I	command, control, communications, and intelligence
CDSTIC	China Defense Science and Technology Information Center
CMC	Central Military Commission
COSTIND	National Defense Science, Technology and Industry Commission
CSES	Chinese Systems Engineering Society
DMSI	Data Memory Systems, Inc.
DSMC	Defense Science and Management College
FSU	Former Soviet Union
FYP	Five-Year Plan
GSD	General Staff Department
MOR	military operations research
MORAI	Military Operations Research and Analysis Institute
MR	military region
MSE	military systems engineering
NDU	National Defense University
NDUST	National Defense University of Science and Technology
NERC	National Engineering Research Center
OR	operations research
PLA	People's Liberation Army
QJM	quantitative judgment model
R&D	research and development
SAM	surface-to-air missile
SDI	Strategic Defense Initiative
TES	tactical engagement simulation

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